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## INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1980

R. D. Neifeld Technical Publications and Editing Unit

July 1981



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER WEAPON SYSTEMS LABORATORY
BENÉT WEAPONS LABORATORY
WATERVLIET, N. Y. 12189

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ARLCB-TR-80044		A093482
ARLCB-TR-80045		A094711
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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-80001		
4. TITLE (and Subtitie)		S. TYPE OF REPORT & PERIOD COVERED
THE EFFECTIVENESS OF TUBE EXTENSION REDUCING VIPER IMPULSE NOISE	S FOR	
	183	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(a)
Dr. G. C. Carofano		
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Benet Weapons Laboratory	10100	AMCMS No. AloR0097A1290
Watervliet Arsenal, Watervliet, N.Y	. 12189	DA Project No. 1X464623D07212
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Impulse Noise Blast Simulator Rocket Launcher Recoilless Rifles

#### 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Using the Benet Weapons Laboratory blast simulator, a study was made to determine the noise reducing characteristics of various geometrical extensions to the tube of a VIPER rocket launcher. It was found that a simple straight extension was the most effective. The reduction is achieved by moving the noise source downstream by the length of the extension and by turning the flow axially which modifies the disturbance which travels upstream.

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STRESS SINGULARITY AT THE VERTEX OF A FLAT W	EDGE-  5. PERFORMING ORG. REPORT NUMBER
SHAPED CRACH BY VARIATIONAL METHOD	3. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(#)	8. CONTRACT OR GRANT NUMBER(*)
M. A. Hussain	
B. Noble	
S. L. Pu	
9. PERFORMING ORGANIZATION NAME AND AODRESS Benet Weapons Laboratory	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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DRDAR-LCB-TL	DA Project No. 1L1161102H60
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#### 18. SUPPLEMENTARY NOTES

Presented at 1979 ASME-CSME Applied Mech/Bioengineering Conf/Fluid Eng Conf, Niagara Hilton Hotel, Niagara Falls, NY, 18-20 June 1979.

Presented at 2nd MACSYMA Users' Conf, Washington, DC, 20-22 June 79.

To be published in an open literature journal.

19. KEY WOROS (Continue on severee side if necessary and identify by block number)

Variational Method

Spherical Harmonics

Flat-Wedge-Shaped Crack

Mixed Boundary Value Problems

Stress Intensity Factors

Fracture Mechanics

Papkovitch Stress Functions

#### 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Three dimensional elasticity problems are generally complex. In this paper we present the analysis for the stress singularity at the apex of a three dimensional, flat, wedge-shaped crack under general loadings. The problem is reduced to a set of coupled dual integral equations. Because of the complexity they are not amenable to a closed form solution. A variational method is developed to handle such problems. The physical interpretation of the results is also presented.

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TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED		
M201 Cannon Land Damage -				
a first Look				
		6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(*)		S. CONTRACT OR GRANT NUMBER(S)		
M. A. Hussain and S. L. Pu				
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		
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Cannon Tube - M201	Ramming	Velocity		
Contact Stress		ent Velocity		
Compliance		le Kinetic Energy		
Land Damage	- 10,000	TO WINDLE THEIR		

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this preliminary investigation is to compute by analytic techniques the conditions which will lead to land damage either in the axial or the radial mode under fully or partially autofrettaged conditions and to estimate the safe ramming velocities.

Land Damage

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4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED				
Simulation of Partial Autofrettage					
Residual Stresses by Thermal Loads					
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7. AUTHOR(a)	8. CONTRACT OR GRANT NUMBER(8)				
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M. A. Hussain J. D. Vasilakis					
S. L. Pu P. O'Hara					
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Autofrettage Residual Stresses Thermal Stresses

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The effect of favorable residual stresses of an autofrettaged tube is well known. In many instances there is a redistribution of these stresses due to changes of geometrical configurations such as the presence of keyways, riflings, cracks, etc. The problem, in general, can be studied by discretization carried out either by finite elements or by finite differences; however, it is usually not possible to incorporate the redistributed residual stress patterns due to the presence of such geometrical changes. This

#### 20. Abstract (Cont'd)

difficulty is overcome by simulation of residual stresses by certain active loadings.

The simulation by dislocation and equivalent thermal loading for a fully autofrettaged tube is well known. In this report we extend the thermal loading to simulate a partially autofrettaged case. The simplicity of the method is illustrated by comparing numerical results to those obtained from finite elements (NASTRAN) and finite differences.

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REPORT NUMBER 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER		
ARLCB-TR-80005			
Stress Analyses of O.D. Notched Thick-Walled Cylinders Subjected to Internal Pressure or	5. TYPE OF REPORT & PERIOO COVERED		
Thermal Loads	6. PERFORMING ORG. REPORT NUMBER		
J. A. Kapp and G. A. Pflegl	3. CONTRACT OR GRANT NUMBER(*)		
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#### 18. SUPPLEMENTARY NOTES

To be presented at the Pressure Vessel Conference ASME, San Francisco, August 1980

19. KEY WOROS (Continue on reverse side if necessary and identify by block number)

Autofrettage Finite Elements Thermal Stress

Stress Concentration Factor

NASTRAN

#### 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Finite element stress analysis has been performed to determine the effects of two OD notch configurations in a cylinder subjected to internal pressure, or containing autofrettage residual stress. The effects on the residual stresses were determined by simulating these stresses with active temperature loads. The results show that the deeper of the two notch configurations is far more severe resulting in a maximum stress concentration factor of 5.8. The shallower notch has a maximum stress concentration factor of 3.5.

#### 20. ABSTRACT (Cont'd)

An additional result is that by introducing notches in autofrettaged cylinders a significant amount of the residual stresses are relieved which indicates that smaller applied pressures can be contained by these cylinders, than in smooth cylinders before yielding occurs. The results also show that the possibility of OD initiated fatigue failure is greatly increased.

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Mortar Systems Mortar Ammunition Mortar Test Data  ABSTRACT (Continue on reverse side if necessary and identity by block number) Reports of an improved 81mm TAMPELLA Mortar System having a maximum ra 500 meters resulted in the establishment of a project with the U.S. Army	ange Fore Conta

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SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered) (Continued from Block 20.) good accuracy. Arena fragmentation tests to evaluate the lethality of a controlled fragmentation (COFRAM) round for the TAMPELLA 81mm Mortar revealed this round to be significantly more lethal than the U. S. 81mm M374 PMI cartridge.

REPORT DOCUMENTATION	READ INSTRUCTIONS BEFORE COMPLETING FORM					
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER				
ARLCB-TR-80007						
4. TITLE (and Subditio) Development and Operation of 8 Inc ESR Furnace at Watervliet Arsenal	5. TYPE OF REPORT & PERIOD COVERED  6. PERFORMING ORG. REPORT NUMBER					
W. Sullivan V. Colangelo		8. CONTRACT OR GRANT NUMBER(*)				
US Army Armament Research and Deve Benet Weapons Laboratory, DRDAR-LC Watervliet, N.Y. 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.7550  DA Project. PRON No. M1-5-A1731  12. REPORT OATE					
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18. SUPPLEMENTARY ROTES						
19. KEY WOROS (Continue on reverse side if necessary an	d identify by block number	)				
ESR Melting Hollow Steel Ingots Steel Castings Servo Systems Slag Furnace (ESR)						
This report is an evaluation of a contractor furnace (ESR) for use in laboratory experiments in melting solid and hollow ingots. The report describes the condition of the furnace as installed, the problems encountered together with the design changes made in-house to correct the existing deficiencies. The report also indicates the technical areas that must be explored to fully develop a hollow ingot technology.						

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IMPROVED LC CHROMIUM FOR GUN TUBE APPLICATION	
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E. S. Chen	100
W. Baldauf	
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19. KEY WORDS (Continue on reverse side if necessary and identify by block num	nber)
Chrome Plating Adhesion	
LC Chromium Pre-treatment	
Tensile Strength Erosion	
Micro Hardness	and the same of th
20. ABSTRACT (Continue on reverse sink if necessary and identify by block num	ber)
A systematic study was made to optimize condition	ons for plating high quality LC
chromium. The tensile strength, density, hardne	ess, cathode efficiency, and

A systematic study was made to optimize conditions for plating high quality LC chromium. The tensile strength, density, hardness, cathode efficiency, and contents of codeposited hydrogen, oxygen, and nitrogen were determined in samples prepared at 85°C and current densities from 60 to 150 A/dm². The results indicate that to achieve high strength coatings it was necessary to age the plating solution by a pre-electrolysis of 250 A-hr liter and to use current densities in excess of 120 A/dm². Under these conditions, high density (Continued on next page)

Continued from Block 20.

crack-free LC chromium can be plated at a rate three times that of conventional HC chromium. The improved LC chromium has been applied on 20 mm liners and test fired in the M24Al gun. The results showed the LC chromium plated liners had a considerably longer life than the HC chromium plated liners.

The development of a simple qualitative test for evaluating the adhesion of thick brittle deposits to the base metal is described. The test is efficacious in large scale sampling and has been applied to investigate the effects of pretreatment on the adhesion of chromium on gun steel and superalloys. An outgrowth of this work is a new pretreatment for activating superalloys for chromium plating which consists of treating the superalloy anodically in a solution of sulfuric and hydrofluoric acids. A table is presented for comparing this process with other pretreatments.

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	5. PERFORMING ORG. REPORT NUMBER
J. A. Kapp, J.H. Underwood J.C. Newman Jr NASA Langley Resear Hampton, VA 23665	8. CONTRACT OR GRANT NUMBER(*)
Denet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 1218 DRDAR-ICB-TL	9 AMCMS No. 53970M63500 PRON No. 1A924154GGGG
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#### 18. SUPPLEMENTARY NOTES

Presented to ASTM Taskgroup E24.01.05, 30 Oct 79, Pittsburgh, PA. To be published in the Journal of Testing and Evaluation.

# 19. KEY WORDS (Continue on severae eids if necessary and identify by block number)

Calibration Fracture Mechanics

Fracture Testing

Fracture Properties Toughness

# 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A new expression has been developed to calculate K for the C-shaped specimen over a wider range of specimen parameters, namely a/W, X/W, and  $r_1/r_2$ , than had previously been available. The rationale used to derive the expression was to utilize known stress intensity factor solutions for short and deep cracks to develop a nondimensional form of K which approaches finite values as a/W goes to both zero and one. Numerical K solution results from prior work were then nondimensionalized to this form with the finite limiting

# 20. ABSTRACT (Cont'd)

values, and the dependence of K on a/W was determined by multi-variable, linear regression. The final expression agrees with the numerical K solutions within  $\pm$  1.0% for .45  $\leq$  a/W  $\leq$  .55 for all  $r_1/r_2$  and X/W of either 0 or .5; within  $\pm$  1.5% for .2  $\leq$  a/W  $\leq$  1 for all  $r_1/r_2$  and X/W equal to 0 or .5; and within about  $\pm$  3% for .2  $\leq$  a/W  $\leq$  1 for all  $r_1/r_2$  and 0  $\leq$  X/W  $\leq$  1. The accuracy of this expression will allow expanded use of the C-shaped specimen for R-curve determination and fatigue crack growth rate testing.

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ARLCB-TR-80010	2. JOYT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
. TITLE (and Subtitie)		5. TYPE OF REPORT & PERIOD COVERED
STRESS CONCENTRATIONS IN SCREW TH	HREADS	6. PERFORMING ORG. REPORT NUMBER
G. P. O'Hara		8. CONTRACT OR GRANT NUMBER(*)
US Army Research and Develop Benet Weapons Laboratory, DRD Watervlietn N.Y. 12189	ment Command	AMCMS No. 4111.16.2991.6 PRON No. 1A-9-39362-Y
US Army Armament Research and Dev Large Caliber Weapon Systems Labo Dover, New Jersey 07801	oratory	13. NUMBER OF PAGES
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17. OISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

#### 18. SUPPLEMENTARY NOTES

Presented at the 8th NASTRAN Users' Colloquium, Goddard Space Flight Center, Oct 79.

To be published in the proceedings of the 8th NASTRAN Users' Colloquium.

## 13. KEY WORDS (Continue on reverse eide if necessary and identify by block number)

Failure

Stress-Concentration

Fatigue

Lugs

Screw-thread

## 20. ABSTRACT (Continue on reverse side if nacessary and identify by block number)

The concept of stress concentration in screw threads is defined as a ratio of maximum fillet stress normalized to shear transfer rate. The data is presented as a plot of fillet stress vs. radial stress for a particular thread form. The Heywood equation is used to generate the basic plots and NASTRAN is used to extend the analysis to the case both where flanks of an individual thread tooth are in contact and the case where a finite axial stress is superimposed.

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REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-80011		
TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED
Benefits of Overload for Fatigue (	Cracking	
at a Notch		
		6. PERFORMING ORG. REPORT NUMBER
AUTHOR(a)		3. CONTRACT OR GRANT NUMBER(#)
J. H. Underwood		
J. A. Kapp		
PERFORMING ORGANIZATION NAME AND ADDRES		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research and Dev	-	AMCMS No. 6446.30.0640.0
Benet Weapons Laboratory, DRDAR-L	CB-TL	DA Project.
Watervliet, N.Y. 12189		PRON No. 4A0216591A1A
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#### 18. SUPPLEMENTARY NOTES

To be presented at 13th National Symposium on Fracture, 9-12 June 1980, Philadelphia, Pa. To be published in ASTM Special Technical Publication

19. KEY WORDS (Continue on reverse side if naceessry and identify by block number)

Fatigue Crack Residual Stress Fracture Mechanics Notch Overload

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

Tests are described which measure the effect of compression overload on fatigue crack initiation and growth from a 0.1 mm radius notch in alloy steel K<sub>IC</sub> specimens. Other tests are described which measure the effect of tension overload on fatigue crack initiation and growth from a 3.4 mm root radius notch in similar specimens. The effect of overload on the number of cycles required for crack growth is described for both types of tests in relation to a residual stress model.

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4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
Review of Recent Literature on		
Palladium Hydrides		•
		6. PERFORMING ORG. REPORT NUMBER
7- AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(#)
D. M. Gray		
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Benet Weapons Laboratory, DRDAR-LCB	-TL	DA Project 1461102HA60
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Superconductivity	Pa11	adium
Enhanced T	Hydr	
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20. ABSTRACT (Continue on reverse side if necessary and is		`
The motivation for this report people's articles, computations, etc (where M is a metal, particularly a thing close to an exhaustive review and Wuhl in "Hydrogen in Metals II," and A. C. Switendick, Ibid, Reference examine and tie together a number of experimentation to test these ideas.	. re superconduction oble metal). The control of th	This is not meant to be any- ly the article by Stritzker and Volk1, 1978, Reference 1
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4. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED
The Austenitizing Behavior of a Low Al		
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(#)
Peter A. Thornton		
9. PERFORMING ORGANIZATION NAME AND ACCRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research and Develop	ment Command	AMCMS No. 3110T12000
Benet Weapons Laboratory, DRDAR-LCB-T	Ľ	DA Project.
Watervliet, N.Y. 12189		PRON No. 1A8241721A1A
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Austentizing Behav		hemical Segregation
Low Alloy Steel Fo	orgings H	eat Treatment
20. ABSTRACT (Continue on reverse side if necessary and ide	ntify by block number)	
The austenitizing behavior of a l	ow allov stee	1 was examined from both the
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The austenitizing behavior of a low alloy steel was examined from both the microstructual and the mechanical property standpoint. The temperature range over which austenitizing took place was accurately determined by metallographic and analytical techniques.

Metallographic evidence showed that the dissolution of carbide continues after the crystallographic transition is completed. Also, the dissolution of the preponderance of carbide coincides with a "leveling-off" trend in mechanical

# 20. ABSTRACT (Cont'd)

property response, viz., yield strength and Charpy impact toughness.

The data demonstrated that a minimum temperature of  $774^{\circ}$  C ( $1425^{\circ}$  F) can sufficiently austenitize this steel under the appropriate conditions. However, because of chemical segregation invariably found in large forgings, it is sound practice to allow some contingency in the heat treatment parameters that will consistently provide an adequate austenitizing condition in the thickest sections of a component.

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4. TITLE (and Subsisse)	5. TYPE OF REPORT & PERIOD COVERED
Electrodeposition of Tantalum and Tantalum	
Chromium Alloys	
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)	
	8. CONTRACT OR GRANT NUMBER(#)
I. Ahmad	
W. A. Spiak	
G. J. Janz  9. Performing organization name and adoress	10 00000000
US Army Armament Research and Development Command	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Benet Weapons Laboratory, DRDAR-LCB-TL	AMCMS No. 6126.03.H181.2
Watervliet, N.Y. 12189	DA Project.
	PRON No. 1A924 3651A1A
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18. SUPPLEMENTARY NOTES	
Property of Armed Marking of ATMS I W.	04 00 7 1 1000
Presented at Annual Meeting of AIME Las Vegas, Nev	. 24-28 Feb 1980
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)	
Gun Erosion Coating	
Refractory Metals Fused Salt	
Tantalum Electrodepo	sition
Tantalum-Chromium Alloys FLINAK	
Chromium	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)	As a part of a program to
develop erosion resistant coatings for advanced gun	barrels, electrodeposition
of tantalum and tantalum-chromium alloys from fused	FLINAK (eutectic mixture of
LiF-KF-NaF) has been investigated. Tantalum-chromic	um alloys containing 2-6%
chromium were obtained by codepositing tantalum and an electrolyte containing 10 wt% TaF5 (added as K2T)	chromium Irom aF7) and 0.5-1.5% Cr (added
as CrF3), at 800°C and 15-40 ma/cm <sup>2</sup> current density	The allow continue
smooth and columnar in structure. The microbardness	of these continue in

creased with the increase of chromium content.

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TITLE (and Subtitle)	S. TYPE OF REPORT & PERIOD COVERED		
Comparison of Mechanical Properties of 105MM M68			
Gun Tube Forgings			
	6. PERFORMING ORG. REPORT NUMBER		
AUTHOR(*)	8. CONTRACT OR GRANT NUMBER(#)		
H. J. Powis			
PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		
S Army Armament Research & Development Command	AREA & WORK UNIT NUMBERS		
Benet Weapons Laboratory, DRDAR-LCB-TL	AMCMS No. 32970675888		
Natervliet, N.Y. 12189	PRON No. 1A7270501A1A		
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9. KEY WORDS (Continue on reverse side if necessary and identify by block number,	)		
Cannon Tubes			
CCB			
ESR			
Rotary Forging			

are supplied at present by two vendors and the Watervliet Arsenal rotary system A study was initiated to compare mechanical properties of the most recent vendor-supplied tubes with those supplied by them in the past. The vendor-supplied tubes were produced from vacuum degassed steel, whereas the rotary forged tubes were produced from electroslag remelted (ESR) steel. The study shows that the quality of tubes, in terms of mechanical properties varies between vendors, but that the quality from each vendor has remained fairly constant. The study also shows that the tubes produced from ESR are equivalent to those produced by conventional forging and heat treating techniques.

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I. REPORT NUMBER	REPORT NUMBER 2. GOVT ACCESSION NO.				
ARLDB-TR-80016					
A Proposed Standard Round Compact Specimen for Plane Strain Fracture Toughness Testing		5. TYPE OF REPORT & PERIOD COVERED  6. PERFORMING ORG. REPORT NUMBER			
J. H. Underwood J. C. Newman, Jr. R. R. Seeley		8. CONTRACT OR GRANT NUMBER(a)			
US Army Armament Research & Develop Benet Weapons Laboratory, DRDAR-LCB Watervliet, N.Y. 12189	oment Command 3-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 61102H420011 DA Project 1L161102AH42 PRON No. 1A927034GGGG			
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US Army Armament Research & Develop Large Caliber Weapon System Laborat Dover, New Jersey 07801	oment Command	May 1980 13. NUMBER OF PAGES 23			
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To be published in the Journal of Testing and Evaluation					
19. KEY WORDS (Continue on reverse eide if necessery and	d identify by block number	)			
Fracture Tough Standard Speci		ound Bar tress-Intensity Factor			
20. ABSTRACT (Continue on reverse side if necessary and					
A round, disk-shaped specimen for addition to ASTM Method E-399. it is loaded in the same general way Tests and analyses are describ proposed round compact specimen and standard K <sub>T</sub> test. The use of the rests is described.	vas the existin ed which were p associated K so	g standard compact specimen. erformed to verify that the lution are appropriate for a			
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TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
STRESS ANALYSIS OF A MORTAR BASEPLATE AS THE BASIS FOR FATIGUE TESTING	
	6. PERFORMING ORG. REPORT NUMBER
· AUTHOR(*)	8. CONTRACT OR GRANT NUMBER(#)
G. P. O'Hara	
PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL	AMCMS No. 20801534000 PRON No. 1A7327Y2GGM7
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DRDAR-LCB-RA, Watervliet Arsenal, Watervliet, N.Y. 12189

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on revetee side if necessary and identify by block number)

Stress Fatigue Mortars

Strain Soil.

Spectrum

Baseplate

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report uses a 5155 degree of freedom static finite element model of the M3 mortar baseplate to provide stress information for a fatigue test design. By using 13 different loading cases and three different soil approximations it is shown that fatigue life varies greatly with different firing conditions. This data also compares favorably with strain gage field test results. A method of designing the fatigue test is suggested; however, it could not be carried out because of a lack of data on field use. A test procedure is suggested based on available information.

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
ARLCB-TR-80018	3. RECIPIENT'S CATALOG NUMBER
STRESS ANALYSIS OF AN OVERLOADED BREECH RING	S. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
P. C. T. Chen and Y. F. Cheng	8. CONTRACT OR GRANT NUMBER(#)
Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL	IO. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 36KA7000204 DA Project No. 156401813GRN PRON No. 1A0215641A1A
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18. SUPPLEMENTARY NOTES

To be presented at International Conference on Reliability, Stress Analysis and Failure Prevention at Hilton Hotel, San Francisco, 18-21 August 1980. To be published in Proceedings of the Conference, ASME Transactions.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Breech Ring

Photoplasticity

Finite Element Analysis

Residual Stress

Failure Prevention

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A two-dimensional model of the meridian section of a breech ring was made of a photoplastic material which had been calibrated optically and mechanically. The location and magnitude of the maximum fillet stress in an overloaded breech ring was determined experimentally and numerically. Residual stress resulting from elastic unloading was calculated. The comparison between numerical and experimental results is satisfactory.

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ARLCB-TR-80019		
4. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED
VARIATIONAL METHODS OF CONVOLUTION	ON INTEGRAL	
AND OF LARGE SPRING CONSTANTS - A	NUMERICAL	
COMPARISON		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(#)
Julian J. Wu		,
Julian J. Wu		
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Benet Weapons Laboratory		AMCMS No. 36KA7000204
Watervliet Arsenal, Watervliet, NY	12189	DA Project No. 156401813GRN
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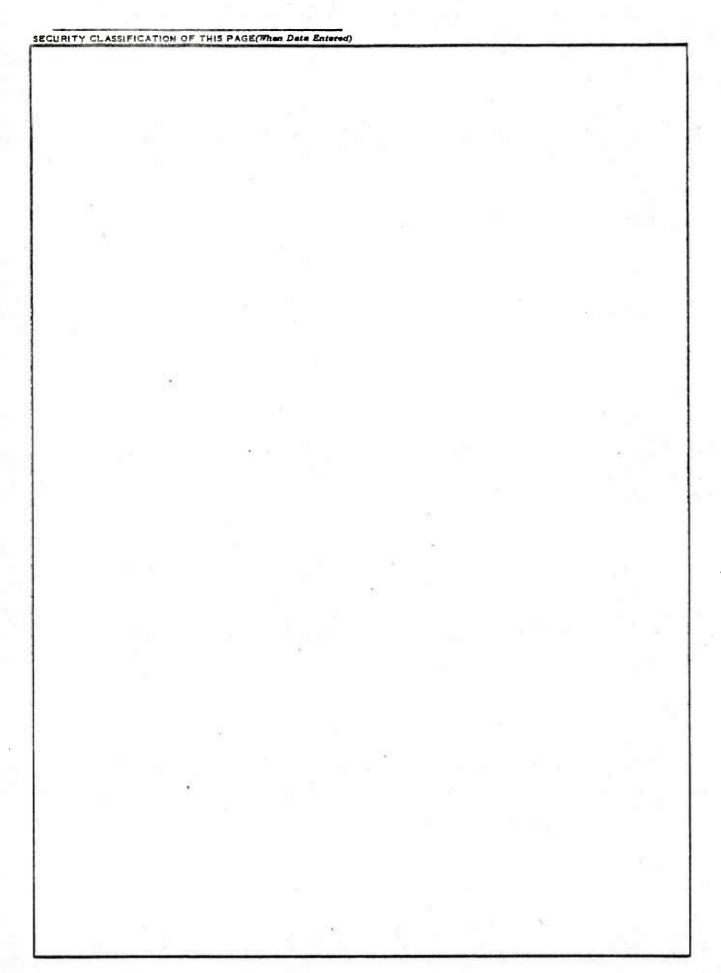
Presented at the Army Numerical Analysis & Computer Conference, NASA Ames Research Center, Moffett Field, CA, 20-21 February 1980.

#### 19. KEY WOROS (Continue on reverse side if necessary and identify by block number)

Variational Methods Finite Elements Convolution Integrals Initial Value Problems

## 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Finite element solution formulations have been carried out for a simple initial value problem based on two different variational statements: that of convolutional integral developed by Gurtin and that of large spring constants adapted by this writer for initial value problems. Numerical results indicate that both generate convergent solution to the given initial value problem of a spring-mass system subjected to a harmonic forcing function.



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4. TITLE (and Subtitie)	5. TYPE OF REPORT & PERIOD COVERED
FACTORS INFLUENCING THE DURABILITY	
OF CHROME PLATE	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(e)	8. CONTRACT OR GRANT NUMBER(*)
R. S. Montgomery and F. K. Sautter	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research and Development Command	AMCMS No. 611102H.600011
Benet Weapons Laboratory, DRDAR-LCB-TL	DA Project No. 1L1611102AH60
Watervliet, N. Y. 12189	PRON No. 1A825497GGGG
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## 18. SUPPLEMENTARY NOTES

Presented at the International Conference on Wear of Materials 1979, Dearborn, Michigan, April 1979. Published in technical journal Wear, Volume 60, 1980, pages 141-148.

19. KEY WORDS (Continue on reveree side if necessary and identify by block number)

Electroplating

Chromium

Wear

Bainite

# 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The bores of many cannon tubes are electroplated with chromium. This is done to provide better resistance to erosion and wear and in the case of naval guns to provide corrosion resistance as well. The resistance of chrome plate to erosion and wear is so good that there is little or no wear of the bore until the chromium begins to spall off the steel substrate. In the present research the effects of various factors on the durability of the plate were investigated using a geared roller test machine. It was found that the

## 20. Abstract (Cont'd)

important stress is the shear stress in the plane normal to the direction of rolling rather than the maximum shear stress; this corresponds to the maximum shear strain. This result has application to the subcase fatigue or "case crushing" failure of case-hardened gears. The failure on repeated loading was found to be in the substrate steel immediately below the interface rather than at the interface itself. The durability of the plated surface decreased by about half as its thickness was increased from 0.15 to 0.41 mm although most or all of this can be attributed to the increased shear stress near the interface for the thicker electroplates. It was also found that residual compressive stress in the substrate steel had a great effect on durability; even the mild residual compressive stress introduced into the steel surface by sand blasting before plating increased durability many-fold. Finally it was found that a bainite microstructure rather than the usual tempered martensite caused a significant decrease in durability.

REPORT DOCUMENTATION F	PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
ARLCB-TR-80021	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
SURFACE CRACK K-ESTIMATES AND FATIGE LIFE CALCULATIONS IN CANNON TUBES	UE	5. TYPE OF REPORT & PERIOD COVERED  6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(=) J. H. Underwood and J. F. Throop		8. CONTRACT OR GRANT NUMBER(*)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Develo Benet Weapons Laboratory, DRDAR-LCB- Watervliet, N.Y. 12189		O PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H420011 DA Project No. 1L161102AH42 PRON No. 1A0217141A1A
US Army Armament Research and Develous Army Armament Research and Develous Large Caliber Weapon Systems Laborate Dover, New Jersey 07801	tory	June 1980 13. Number of Pages 16
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

### 18. SUPPLEMENTARY NOTES

Published in Special Technical Publication 687, Copyright 1979, American Society for Testing and Materials, Philadelphia, Pennsylvania.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fracture Mechanics

Surface Crack

Crack Propagation

Fatigue (Material)

Fatigue Life

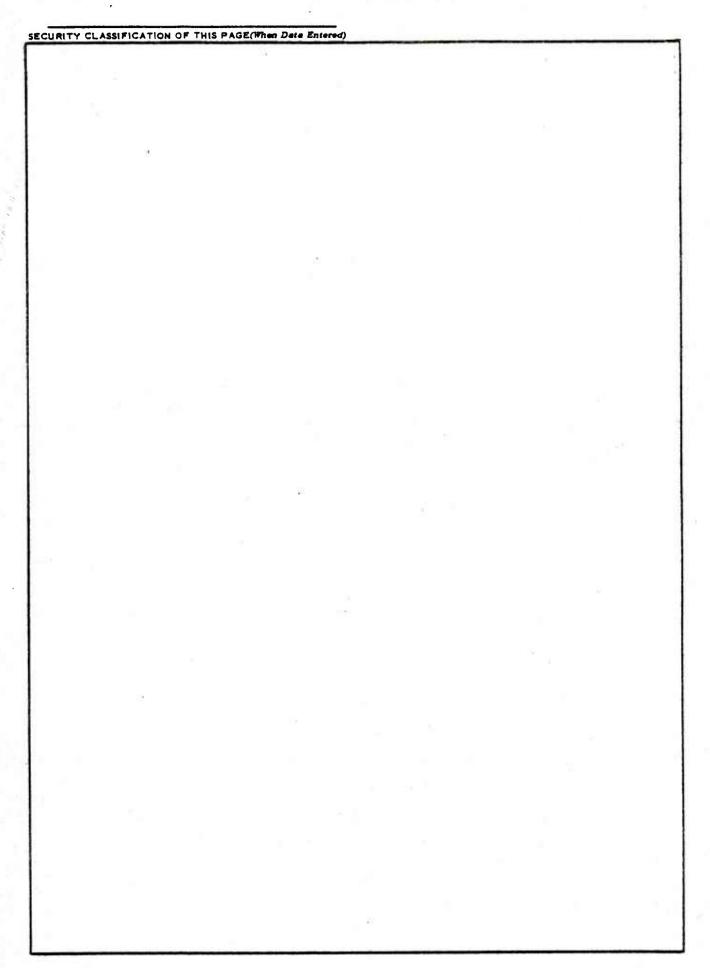
Residual Stress

Pressurized Cylinder

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

K solutions for internal surface cracks in pressurized cylinders are compared, including Smith's photoelastic results, Hussain's collocation and compliance results, and Underwood's estimates. Fatigue crack growth observations from cannon tubes are described, particularly in relation to surface crack growth and multiple cracks.

A method is proposed for describing quantitatively the effect of residual stress on K in cylinders with shallow cracks. The combination of compressive residual stress with applied stress reduces AK and thus increases fatigue life.



REPORT DOCUMENTATION	READ INSTRUCTIONS BEFORE COMPLETING FORM	
. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-MR-80022		
4. TITLE (and Subtitle) DESIGN AND CONSTRUCTION OF A REFINE THREADING MACHINE FOR 175mm AND 8"	S. TYPE OF REPORT & PERIOD COVERED  S. PERFORMING ORG. REPORT NUMBER	
C. H. Rose		8. CONTRACT OR GRANT NUMBER(#)
US Army Armament Research and Develores Benet Weapons Laboratory, DRDAR-LC Watervliet, N.Y. 12189	-	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.6771 PRON No. NI-4-A1632-01-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		June 1980  13. Number of pages 22
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### 18. SUPPLEMENTARY NOTES

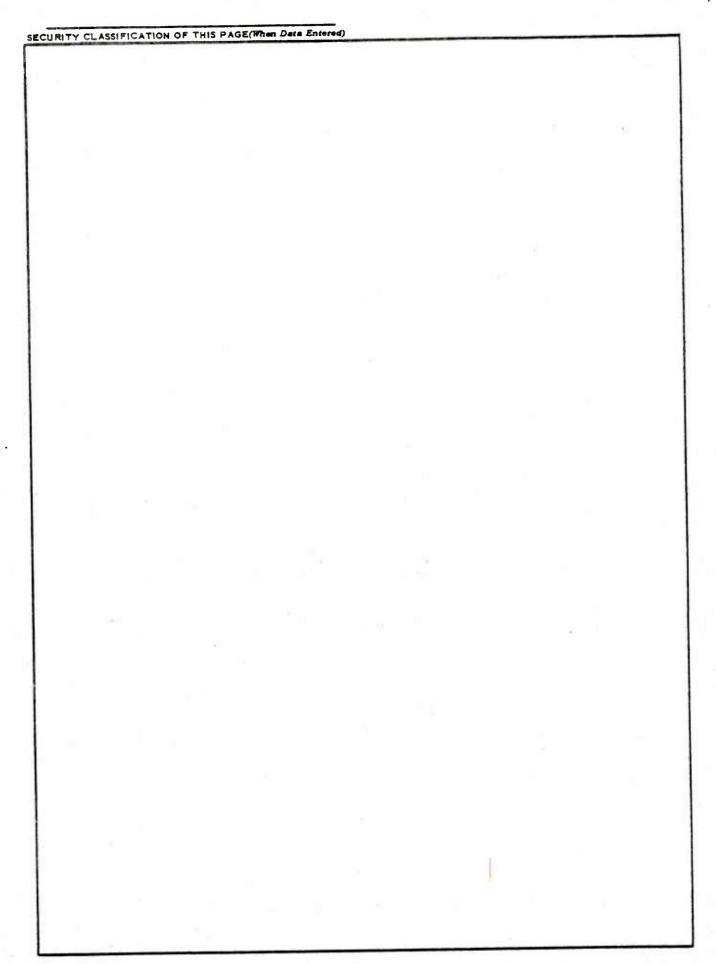
Originally submitted as an MM&T project to U.S. Army Armament Materiel Readiness Command in April 1980.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Thread Cutting
Step Threads
Thread Shaping
Form Tool Threading

# 20. ABSTRACT (Cantinus on reverse side if necessary and identity by block number)

This report details the engineering design and production application of a special purpose machine, tooled to produce internal step threads (constant lead thread on two distinct diameters) on 8" M201 breech rings. The machine, using oscillating motion and a full thread form tool, produces the full thread on each sector, then is indexed in turn to the next sectors until all eight (8) are complete. The use of this equipment has reduced the floor to floor time from 13 hours to 4 hours while producing better thread finishes and more accurate dimensional sizes.



REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
. REPORT NUMBER 2. GOVT	ACCESSION NO. 3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-80023	
. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVEREO
LASER TREATMENT OF CHROMIUM PLATED STEEL	
	5. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(e)	8. CONTRACT OR GRANT NUMBER(s)
R. S. Montgomery	
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#### 8. SUPPLEMENTARY NOTES

Presented at the 4th International Tribology Conference, Paisley, 10-15 September 1979.
Published in technical journal Wear, Volume 56, 1979, pages 155-166.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Electroplating

Chromium

Wear

Heat Affected Zone

Laser Treatment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Both flat steel coupons and rolls for a geared-roller test machine were chromium plated and laser treated in an effort to improve adhesion. Under the experimental conditions the electroplate was rendered considerably softer but more fragile. A Cr-Fe alloy was produced at the interface at the slower processing speeds and the steel under the electroplate was considerably hardened by the formation of untempered martensite. While this work shows only much decreased durability for laser-treated chrome plate, perhaps other experimental conditions might show improved properties.

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ARLCB-TR-80024				
4. TITLE (and Subtifle)	S. TYPE OF REPORT & PERIOD COVERED			
A MATHEMATICAL MODEL FOR PRODUCTION SIMULATION				
	6. PERFORMING ORG. REPORT NUMBER			
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(*)			
E. E. Coppola				
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computerized Simulation
Mathematical Model
Production Model
Production Scheduling

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A mathematical model has been developed to simulate the production lines at Watervliet Arsenal. Inputs to the model include the steps required to transform raw material into a finished product and the resources available for production. From these data, the model will predict such things as the number of items produced by the line, utilization of machines and workers and areas where the number or quality of the resources are not adequate to meet the desired production goals.

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A PHOTOELASTOPLASTIC STUDY OF STRESS CONCENTRATION FACTORS AND RESIDUAL STRESSES IN TWO NOTCHED	5. TYPE OF REPORT & PERIOD COVERE		
SPECIMENS OF POLYCARBONATE MATERIAL	6. PERFORMING ORG. REPORT NUMBER		
Y. F. Cheng	8. CONTRACT OR GRANT NUMBER(*)		
Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 36KA7000204 DA Project No. 156401813GRN PRON No. 1A0215641A1A		
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Photoelasticity
Photoplasticity
Stress Concentrations

Residual Stress C-Shaped Specimen

Compact Tensile Specimen

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

A photoelastoplastic study on stress concentrations, in elastic as well as in elastoplastic states, in a C-shaped specimen and a compact tensile specimen of polycarbonate material has been made. The principles of the experimental method are outlined, equations for nominal stresses are given, and stress concentration factors are determined. Residual stresses after unloading are calculated by making the usual assumption that unloading is an elastic process. In the elastic (CONTINUED)

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REPORT DOCUMENTA	TION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
. REPORT NUMBER ARLCB-TR-80026	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
. TITLE (end Subtitle) FRACTURE TESTS AND ANALYSIS OF 155 MM M549A1 PROJECTILE	F WARHEAD BASE OF	5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
Joseph F. Throop, Robert R. Fu Ronald T. Abbott	ijczak, and	8. CONTRACT OR GRANT NUMBER(#)
Description NAME and A Benet Weapons Laboratory Watervliet Arsenal, Watervliet	11	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612105H840011 DA Project No. 1L162105AH84
DRDAR-LCB-TL		PRON No. 1A0217131A1A
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US Army Armament Research and Large Caliber Weapon Systems I Dover, NJ 07801		August 1980 13. Number of Pages 41
14. MONITORING AGENCY NAME & ADDRESS(#	different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Raport)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

RAP Projectile Fracture Critical Flaw

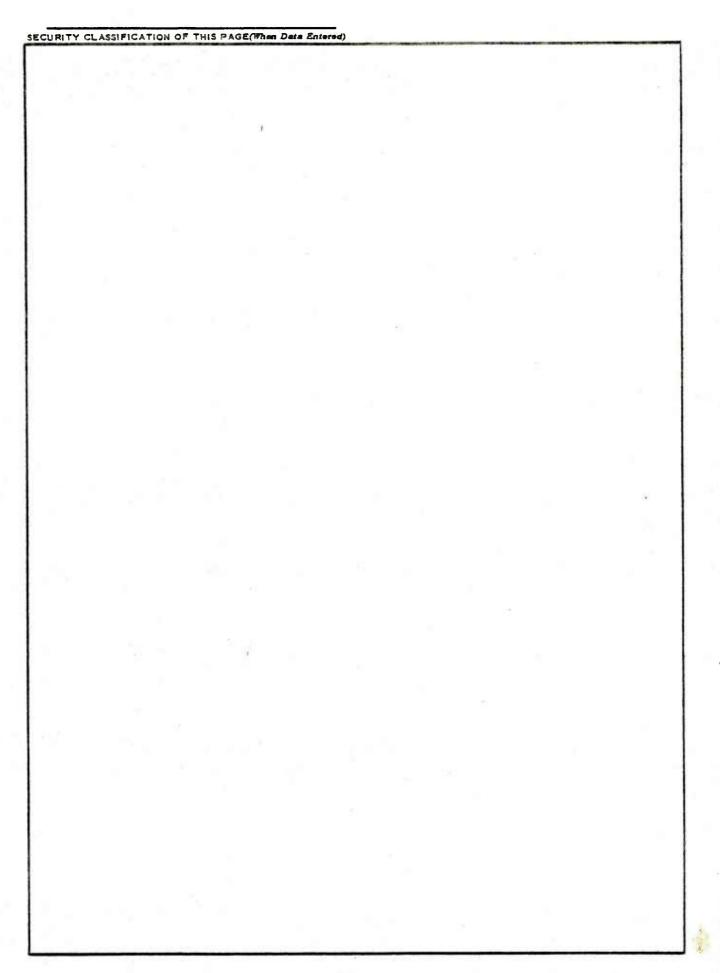
Hydro-test Launch

Acceleration Temperature

## 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An experimental study was conducted to evaluate the propensity for brittle fracture of the warhead base of the 155 mm Rocket Assisted Projectile M549Al during launch and to provide samples with known flaw sizes for use in calibration of inspection devices. The experiments also determined the hydrostatic proof test pressure required to fracture the smallest flaw that would be critical at the most severe launch temperature. Fracture mechanics failure analyses and plane strain fracture of the base were confirmed by the experiments.

Inspection



REPORT DOCUMENTAT	TON PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM		
1. REPORT NUMBER ARLCB-TR-80027	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER		
4. TITLE (and Subtitio) STUDY OF EROSION RESISTANT MATE TUBES PART I: 20 MM LINER TE		S. TYPE OF REPORT & PERIOD COVERED		
		6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(=)		8. CONTRACT OR GRANT NUMBER(4)		
R. L. Cullinan, G. D'Andrea, P.	Croteau, and	<b>₫</b> )		
C. Arnold				
PERFORMING ORGANIZATION NAME AND ADD	DRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		
Benet Weapons Laboratory		AMCMS No. 64366280071212		
Watervliet Arsenal, Watervliet, DRDAR-LCB-TL	NY 12189	DA Project No. 1W463628D00		
1. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE		
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18. SUPPLEMENTARY NOTES

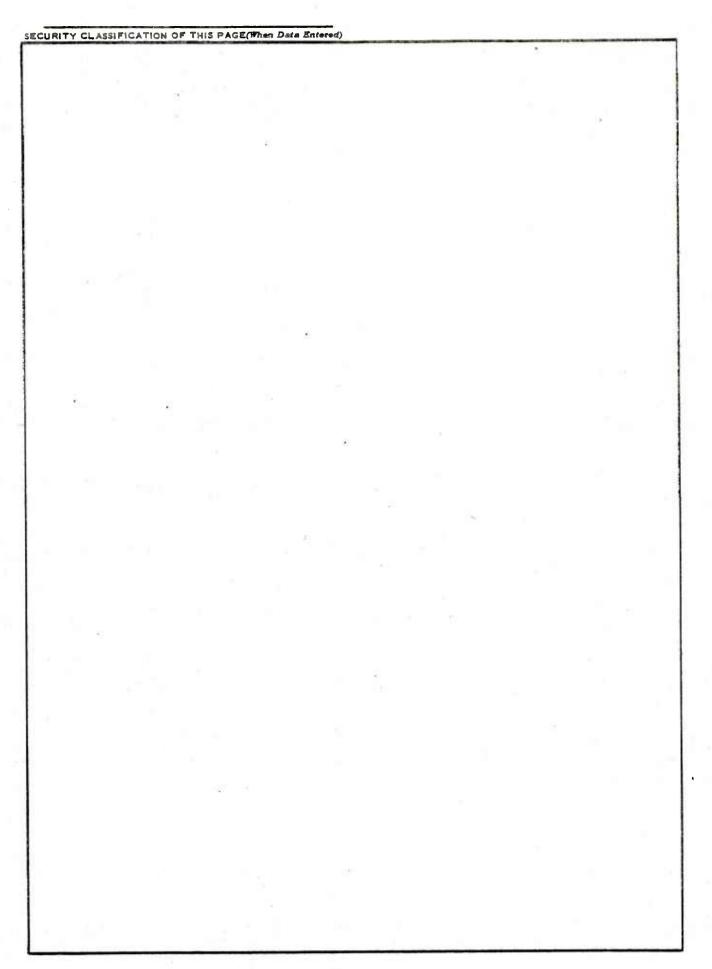
19. KEY WORDS (Continue on reverse eide if necessary and identity by block number)

Gun Tube Erosion Shrink-Fit Liners Bore Plating Tantalum Coatings 20 MM M24Al

Erosion Protection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The major criteria for the condemnation of gun tubes is based on the excessive erosion of the bore which results in loss of range and accuracy. Gun tube erosion is caused by several thermal, mechanical, and chemical factors interacting during the firing cycle. One approach to minimize erosion is to line gun barrels with wear resistant materials. This work introduces a shrink fit liner concept in the 20 mm M24Al gun system. Liners analyzed are steel, Cr/steel, Ta/steel, Ta/stellite. Preliminary firing results, under similar test conditions, indicate that the Ta/steel combination reduces erosion in the 20 mm gun system.



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REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-80028		
. TITLE (end Subsiste) GENERALIZED PLANE-STRAIN PROBLEMS ELASTIC-PLASTIC THICK-WALLED CYLINI		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. Author(s) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(*)
Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY DRDAR-LCB-TL		10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 36KA7000204 DA Project No. 156401813GRN PRON No. 1A0215641A1A
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Presented at the 26th Conference of Army Mathematicians, Cold Regions Research and Engineering Lab, Hanover, New Hampshire, 10-12 June 1980. To be published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identity by block number)
Autofrettage
Elastic-Plastic Deformation
Finite-Difference Method

Gun Tube

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A new finite-difference approach has been developed for solving the generalized plane-strain problems of partially-plastic thick-walled cylinders made of strain-hardening or ideally-plastic materials. The tube is assumed to obey the Von Mises' criterion, the Prandtl-Reuss flow theory and the isotropic-hardening rule. The forces include internal pressure, external pressure, and end force. An incremental approach is used and no iteration is needed for each increment. The approach is simpler than others yet quite general and accurate.

CONT'D ON REVERSE

# 20. Abstract (CONT'D)

The desired accuracy can be achieved by reducing the grid sizes and load increments. Some numerical results for the stresses and displacements in partially-plastic thick-walled cylinders with either open-end or closed-end conditions are presented.

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. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
STRAIN BEHAVIOR OF PRESSURIZED C	RACKED THICK-	
WALLED CYLINDERS		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(*)
J. F. Throop and R. R. Fujczak		
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To be published in Experimental Mechanics.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

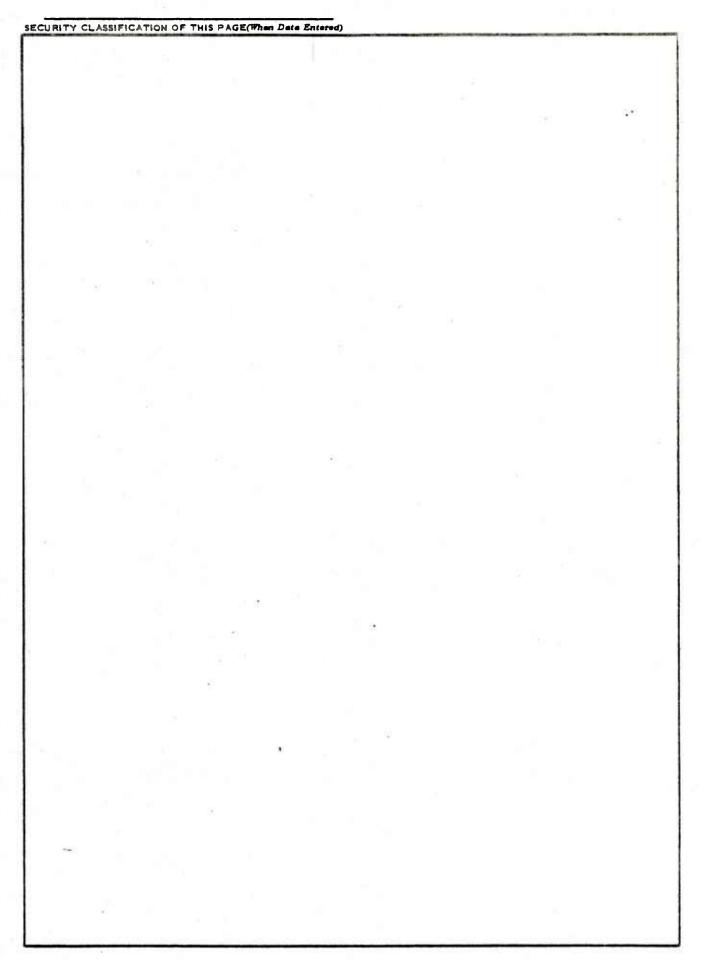
Fatigue Cracks Crack Shape Thick Wall Cylinders

Strain Measurements

Autofrettage Lame Strain Ultrasonics

20. ASSTRACT (Continue on reverse side if necessary and identity by block number)

External circumferential strains were measured on large thick wall pressure vessels containing internal fatigue cracks, using bonded strain gages. When strains measured over the cracks become compressive they predict impending failure. Normalization by the Lame strain relates them to the fraction of fatigue life consumed and provides estimates of longevity.



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4. TITLE (end Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
AN EXPERIMENTAL INVESTIGATION OF ST		
STEEL MODEL OF AN OVERLOADED BREECH OF PHOTOELASTIC COATING TECHNIQUE	I RING BY MEANS	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) Y. F. Cheng		8. CONTRACT OR GRANT NUMBER(#)
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Breech Ring Photoelastic Coating Residual Stress Stress Concentration Factor

20. ABSTRACT (Continue on reverse side if necessary and Identify by block number)

An experimental investigation of stresses at the lower fillet in a two dimensional steel model of an overloaded breech ring by means of photoelastic coating technique has been made. The basis of the technique is given. Expressions for stress and strain in both the elastic and elasto-plastic state are derived. Maximum fillet stress, stress concentration factor, as well as the residual stress after unloading were found. The results were compared with previous data from polycarbonate model.

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DEFLECTION AND PERMANENT DEFLECTION FOR ELASTIC-	
PLASTIC BENDING OF UNSYMMETRICALLY LOADED BEAMS  6. PERFORMING ORG. REPORT NUM	BER
PARTY DESCRIPTION OF CHURCHENING COMPEN DEATH	,
7. AUTHOR(*) 8. CONTRACT OR GRANT NUMBER(	<b>a</b> )
R. V. Milligan	
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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
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MUZZLE FAILURE ANALYSIS 105 mm M68 Ser #26925	5. TYPE OF REPORT & PERIOD COVERED  6. PERFORMING ORG. REPORT NUMBER
Bruce B. Brown and Howard D. McAlonie	3. CONTRACT OR GRANT NUMBER(s)
Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3111.15.11000 PRON No. 1A9204991A1A
1. CONTROLLING OFFICE NAME AND ADDRESS  US Army Armament Research & Development Command  Large Caliber Weapon Systems Laboratory	12. REPORT DATE August 1980  13. NUMBER OF PAGES 24
Dover, NJ 07801  14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	1S. SECURITY CLASS. (of this report)  UNCLASSIFIED  1Se. DECLASSIFICATION/DOWNGRADING SCHEDULE

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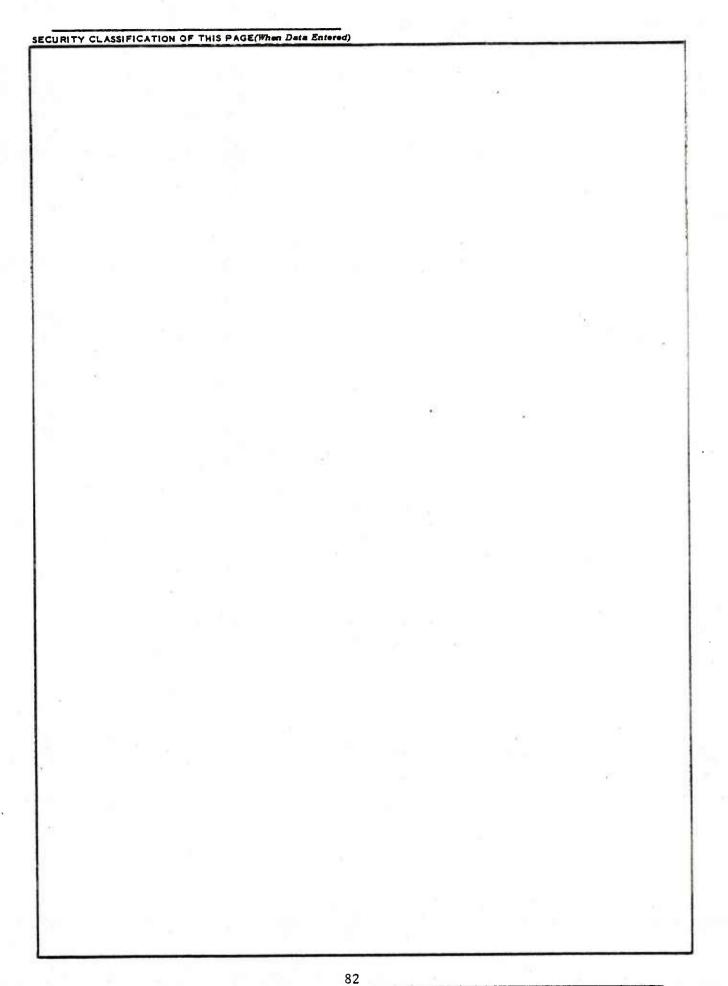
This report is reissued to upgrade the quality of the illustrations.

## 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Cannon 105 mm M68 Tank M60Al Failure Analysis Cannon Barrel Failure

## 20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

An engineering and metallurgical study has been made of 105 mm M68 barrel muzzle that fractured during firing. The barrel steel was within specification limits in mechanical properties, chemistry and cleanliness. The failure is attributed to excess stress in a hoop direction and prior cracking. A residue of aluminum and propellant debris was found adhering to crack surfaces.



SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)	
REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 2. GOVT ACCESSION NO. ARLCB-MR-80033	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Substite) An End Item Manufacturing Process Guide (A Functional Cost Analysis of Manufacturing Operations)	5. TYPE OF REPORT & PERIOD COVERED
sper derions/	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)	8. CONTRACT OR GRANT NUMBER(*)
Harold Goodheim	
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N. Y. 12189	DA Project No. 6717042
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command	12. REPORT DATE August 1980
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19. KEY WORDS (Continue on reverse eids if necessary and identify by block number)

Manufacturing Processes Functional Classification

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to develop a systematic procedure for pin-pointing areas for future funding requests aimed at improving production methods. The approach taken was to describe current manufacturing processes in terms of the functions they performed, thus allowing assessment of costs without reference to the methods employed. Such "technology-independent" assessment allowed cost comparison both within and among end items, thereby highlighting the high-cost functions.

# 20. Abstract (Cont'd)

Based on available data a procedure was designed for developing the Process Analysis Structure - an interrelated set of nine tables which become the analyst's raw materials in the search for new combinations of operations and for high-cost production functions. This procedure including a new method for indirect cost allocation, was validated with actual data relating to the manufacture of the 105mm M68 gun tube.

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REPORT NUMBER	2. GOVT ACCESSION NO.	
ARLCB-TR-80034		
TITLE (and Subtitle) FATIGUE TEST, 155 MM M199 BARR	EL	S. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING DRG. REPORT NUMBER
Bruce B. Brown		6. CONTRACT OR GRANT NUMBER(a)
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INDEX TO BENET WEAPONS LABORATORY (	LCWSL)	
TECHNICAL REPORTS - 1979		6. PERFORMING ORG. REPORT NUMBER
7. Author(a)		8. CONTRACT OR GRANT NUMBER(s)
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1. REPORT NUMBER ARLCB-TR-80036	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (end Substitle) AN ADAPTIVE ALGORITHM FOR EXACT SOLI OF AN OVERSTRAINED TUBE	UTION	5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(*)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY DRDAR-LCB-TL	12189	10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS AMCMS No. 36KA7000204 DA Project No. 156401813GRN PRON No. 1A0215641A1A
11. controlling office name and address US Army Armament Research and Develo Large Caliber Weapon Systems Laborat Dover, NJ 07801	•	12. REPORT DATE September 1980 13. NUMBER OF PAGES 13
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## 18. SUPPLEMENTARY NOTES

Presented at 1980 Army Numerical Analysis and Computer Conference, NASA Ames Research Center, Moffett Field, California, 20-21 February 1980. Published in proceedings of the conference.

#### 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Elastic-Plastic Deformation Finite-Difference Method Gun Tube Residual Stresses

## 20. ABSTRACT (Continue on reverse side if necessary and Identify by block number)

An adaptive algorithm to generate an exact solution has been developed for the plane-strain problem of a thick-walled tube overstrained by internal or external pressure. The material obeys the von Mises' yield criterion, the Prandtl-Reuss flow theory and the isotropic hardening rule. The ideally-plastic material is treated as a special case. The formulation is based on the finite-difference (CONT'D ON REVERSE)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered) Abstract (CONT'D) method in conjunction with a scaled incremental-loading approach. One additional grid point will become yielded in each load step. The grid sizes and load increments are determined in the program. For a given percentage of overstrain and a desired solution necessary, the stresses and strains can be obtained in an efficient way.

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ARLCB-T	R-80037		
A. TITLE (and Subtitle)  DETERMINATION OF PHASE TRANSFORMATION  TEMPERATURES OF TITANIUM-NICKEL USING  DIFFERENTIAL THERMAL ANALYSIS		S. TYPE OF REPORT & PERIOD COVERED	
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US Army Large Ca	NG OFFICE NAME AND ADDRESS Armament Research and Dev Liber Weapon Systems Labo UJ 07801	elopment Command ratory	12. REPORT DATE
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#### 18. SUPPLEMENTARY NOTES

Published in Proceedings of Fourth International Conference on Titanium, Kyoto, Japan, 19-22 May 1980.

19. KEY WORDS (Continue on reverse eids if necessary and identify by block number)

Nickel

Titanium

Nickel-Titanium

Differential Thermal Analysis

Phase Transformations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Some of the more popular methods used to determine phase transformations in metals are x-ray, dilatometry, and electrical resistivity. Data reported for the TiNi alloy using Differential Thermal Analysis (DTA) is quite sparse and it appears that little effort has been made to correlate these results with x-ray, dilatometry, or resistivity data. The purpose of this investigation was to determine the  $M_{\rm S}$  and  $A_{\rm S}$  temperatures for several alloys having compositions (CONT'D ON REVERSE)

## 20. Abstract (Cont'd)

near 50 atomic percent titanium. The DTA method was used. The results are compared with those reported by several investigators that used different techniques. The DTA data obtained shows excellent agreement with Kornilov's Astemperatures, as a function of composition, obtained by dilatometry. A small variation was found between the results of this study and Wasilewski's x-ray data, and Hanlon's resistivity measurements for the Ms temperatures. It is concluded from this investigation that DTA analysis is a credible method for determining phase transformation temperatures for the TiNi material.

REPORT DOCUMENTATION PA	AGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-80038	GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (end Subtitle)  FLUX EXCLUSION IN CdS AT 77 K:  SUPERCONDUCTIVITY AT HIGH TEMPERATUR	RES?	S. TYPE OF REPORT & PERIOD COVERED  6. PERFORMING ORG, REPORT NUMBER
R. K. MacCrone - Rensselaer Polytech Institute, Troy, New York 12180	nnic	8. CONTRACT OR GRANT NUMBER(*)
Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY DRDAR-LCB-TL	12189	O. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600 DA Project No. 1L161102AH60 PRON No. 1A-0-3ZB04-NMLC
US Army Armament Research & Developm Large Caliber Weapon Systems Laborat Dover, New Jersey 07801		12. REPORT DATE October 1980  13. NUMBER OF PAGES 4
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Published in Physical Review Letters, Volume 45, Number 6, 11 August 1980, pages 478-481.

## 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Excitonic Solids
Superconductivity
Flux Exclusion
High Pressure
Semiconducting Materials

# 20. ABSTRACT (Continue on reverse state if necessary and identify by block number)

The observation of flux exclusion approaching Meissner proportions ( $\times v=-1/4\pi$  cgs units) in pressure-quenched CdS at 77 K is reported. The results can be naturally and simply interpreted on the basis of superconductivity at 77 K. If the superconductive state is not the appropriate description, then a new high-temperature collective quantum state must be invoked.

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F. A. Heiser		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
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Rotary Forging			
Steel			
20. ABSTRACT (Continue on reverse side if necessary an			
Electro Slag Refined steel which	had been rotary f	orged from a solid	
20 inch cast ingot into a solid 1	3 inch diameter o	ylinder was evaluated	
metallographically and mechanical	ly. It is shown	that the degree of	
working is not uniform across the	cross section, b	eing greatest near the	
ID and least near the center. The	is degree of work	ing manifests itself	
in the ductility but not in the s prior to quench and temper, lower	ed the vield stre	enoth slightly hut	
markedly improved both the toughn	ess and ductility		

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7. Author(*) P. C. T. Chen	8. CONTRACT OR GRANT NUMBER(*)
Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 121 DRDAR-LCB-TL	10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 36KA7000204  DA Project No. 156401813GRN PRON No. 1A0215641A1A
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Presented at 1980 Army Numerical Analysis and Computer Conference, NASA Ames Research Center, Moffett Field, California, 20-21 February 1980. Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

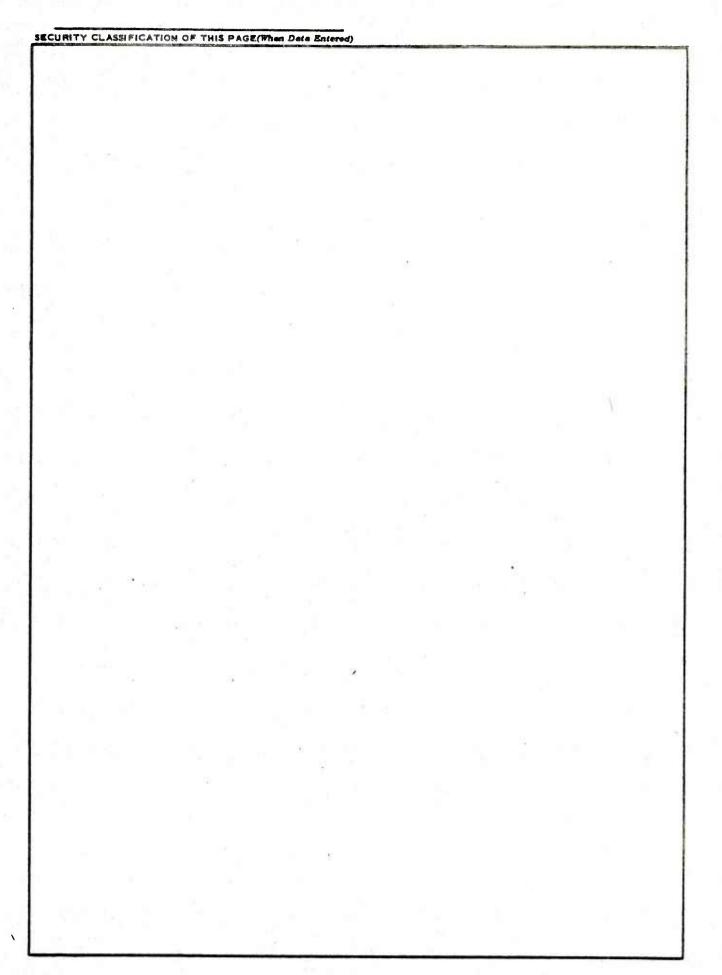
Breech Ring Residual Stress Numerical Technique Elastic-Plastic

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a numerical technique for predicting the residual stresses in an overloaded breech ring. The numerical approach used is the finite element method based on the incremental stress-strain matrix, for which a computer program is developed. The material behavior is characterized by the von Mises' yield criterion, Prandtl-Reuss flow equations and isotropic hardening rule. A piecewise linear representation for the stress-strain (CONT'D ON REVERSE)

curve is used. The numerical results of the stresses in all elements are obtained for four contact conditions. The location and magnitude of the maximum fillet stress are determined as a function of loading. Residual stresses resulting from elastic unloading are calculated. A satisfactory agreement between numerical and experimental results has been reached.

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EFFECT OF OVERSTRAIN IN AUTOFRETTAGE UPON MECHANICAL PROPERTIES OF GUN TUBES	S. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG, REPORT NUMBER
. Author(*) H. Goodheim L. Alix	8. CONTRACT OR GRANT NUMBER(#)
Dr. V. Colangelo	
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and the contract of the contra	
A study was undertaken to determine the effect of overstrain on mechanical properties in gun tubes.	excessive and normal



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FAILURE ANALYSIS - 105mm M68		
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AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(8)
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

**Blockage** 

Catastrophic Failure

Mechanical Properties

Projectile

Yield Strength

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

On 26 October 1978, a 105mm M68 gun tube, SN 17759, failed during the firing of a training round. A failure analysis investigation was undertaken consisting of visual examination, metallography, mechanical property evaluation and chemical analysis. The investigation established that the tube exhibited good mechanical properties, did not contain a pre-existing material defect, and did not fail by an in-bore premature detonation of the projectile. This investigation also concluded that it is possible that (Cont'd)

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ELASTIC-PLASTIC ANALYSIS OF SCREW	THREADS	5. TYPE OF REPORT & PERIOD COVERED
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G. P. O'Hara		8. CONTRACT OR GRANT NUMBER(#)
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Published in Proceedings of the 26th Conference of Army Mathematicians, Cold Regions Research and Engineering Lab, Hanover, New Hampshire, 10-12 June 1980.

## 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Screw Threads

Lugs

Stress

Plastic

Elastic

## 20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

An elastic-plastic analysis method is suggested for screw thread teeth. In this method a single tooth is analyzed using boundary conditions to simulate a long chain of identical teeth. A set of five different loads are suggested to simulate pressure and shear on each flank along with a general stress field in the component. An example is worked out for a British Standard Buttress thread form. Data is presented from the example to show that friction is a very important parameter.

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QUADRATIC AND CUBIC TRANSITION E	ELEMENTS	
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(#)
M. A. Hussain		
J. D. Vasilakis		
S. L. Pu		
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Finite Elements
Transition Elements
Stress Intensity Factors

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Based on the investigations of Barsoum, <sup>1</sup> Henshell and Shaw, <sup>2</sup> quarterpoint quadratic elements have been successfully used as crack tip elements in fracture mechanics. This concept of singular element was extended to cubic isoparametric elements. <sup>3</sup> Recently it was discovered by Lynn and Ingraffea <sup>4</sup> that under special configuration, transitional elements improve the accuracy of stress intensity factor computations. In this report, we have obtained (CONT'D ON REVERSE)

### 20. ABSTRACT (Cont'd)

the location of mid-side nodes of these transitional elements for the quadratic as well as cubic elements. The cubic transitional elements were used for the double-edge crack problem, and it was found that there was improvement in accuracy for a configuration which consisted only of singular and transitional elements. However, for a well laid out grid, the improvement was only marginal.

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ELASTIC-PLASTIC ANALYSIS USING A TRIA	NGULAR
RING ELEMENT IN NASTRAN	6. PERFORMING ORG. REPORT NUMBER
AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(#)
P. C. T. Chen	
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#### 18. SUPPLEMENTARY NOTES

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Published in proceedings of the colloquium.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

NASTRAN Program Triangular Ring Elastic-Plastic Gun Tube Thread Problem

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

An elastic-plastic triangular ring element is implemented in the NASTRAN computer program. The plane-strain problem of a partially-plastic thick-walled cylinder under internal pressure is solved and compared with the earlier finite-difference solution. A very good agreement has been reached. In order to demonstrate its application to more general problems, an overloaded (CONT'D ON REVERSE)

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· Author(s) Julian J. Wu		8. CONTRACT OR GRANT NUMBER(*)
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### 18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Moving Loads

Finite Element

Dynamics

Vibrations

Beam

ABSTRACT (Continue on reverse side if necessary and identify by block number)
A solution formulation and numerical results are presented here for the timedependent problem of beam deflections under a moving load which can be neither a force nor a mass. The basis of this approach is the variational finite element discretization consistent in spatial and time coordinates. The moving load effect results in equivalent stiffness matrix and force vector which are evaluated along the line of discontinuity in a time-length plane. Numerical results for several problems have been obtained, some of which are compared with solutions obtained by Fourier series explanations.

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T. E. Simkins	8. CONTRACT OR GRANT NUMBER(#)
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18. SUPPLEMENTARY NOTES To be published in American Institute of Aeronautics & Astronautics (AIAA).

19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Finite Elements

Dynamics

Boundary Value Problems

Approximations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The work of C. D. Bailey amply demonstrates that a variational principle is not a necessary prerequisite for the formulation of variational approximations to initial value problems in dynamics. While Bailey successfully applies global power series approximations to Hamilton's Law of Varying Action, the work herein shows that a straightforward extension to finite element formulations fails to produce a convergent sequence of solutions. The source of the (CONT'D ON REVERSE)

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fff	culties		elimination are	discussed in	some detai	il and a work	cable
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